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CROSS-SCAN INVESTIGATION FOR CLOSED CIRCUIT TELEVISION. (U)

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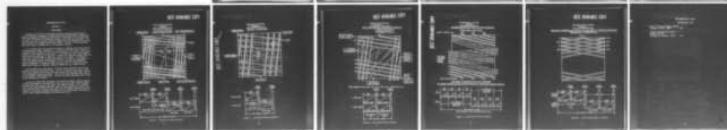
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increased area scanned.

Five different cross-scan schemes were investigated. While each method yielded an increase in area coverage and, therefore, an increase in picture information, sub-area flickering was a problem in all but one. It was concluded that the cross-scanning technique can produce a flicker-free raster with a more pleasing and somewhat less conspicuous pattern. To achieve any significant improvement in line structure appearance with the cross-scanning technique, it is necessary to start at double the scan number for any given standard scan number for which a comparison is to be made. As the scan number is increased, the bandwidth must also be increased and system noise becomes more of a problem. In light of these findings, it was further concluded that cross-scanning can provide an improvement at the lower scan numbers, but this improvement diminishes for the higher scan numbers.

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### SECTION I

#### INTRODUCTION

A problem of using television displays for training devices is the appearance of the line structure of the raster which is used to generate the two-dimensional picture of the face of a television CRT viewed directly or as projected on a screen by means of a television projector. A standard television raster is formed by horizontal scan lines wherein a first field is generated on every other line space and a second field, an interlace field, is generated on the line spaces between the first field. For a low scan number, the total number of television raster scan lines generated, the spaces between the lines are conspicuous and are distracting to the viewer when the display is used to simulate a real world scene for training purposes.

In view of the stated problem, an investigation was performed to determine the feasibility of utilizing a cross-scan raster to decrease the marked appearance of the line structure.

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### SECTION II

#### STATEMENT OF THE PROBLEM

The need exists for training device displays to be relatively free from distracting effects. Line structure appearance resulting from the generation of the television raster, is a distracting effect, especially when the total number of scan lines used is small compared to the space which must be filled by the raster. Such rasters when compacted on a small CRT present a fairly uniform picture and the line structure is generally not detectable from the normal viewing distance. When the same number of scan lines are used in a projection system, the space between the lines is magnified many times and gives the appearance of viewing the scene through a partially open venetian blind.

The need to minimize line structure appearance can be partially satisfied by increasing the total number of scan lines. This solution gives rise to other problems such as increased bandwidth requirements and the resultant system noise. Little was known as to the effectiveness of different types of scan systems to satisfy this need. The objective of this task was to make this determination.

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### SECTION III

#### PROCEDURE

The procedure followed in attacking this problem consisted of: (1) conceiving various scan systems which featured cross-scanning; (2) breadboarding deflection and switching circuits to produce the desired rasters on a CRT; (3) observing the effects of the resulting displays.

Lacking a CRT with electrostatic deflection, a Tektronics 547 Oscilloscope was selected to serve as a monitor. Breadboard deflection and switching circuits were designed to produce the desired raster on the 547. The COHU sync generator was utilized to produce the required TV system timing and blanking pulses. The generator provided for a basic 1029 scan line system with 2:1 interlace; this produced a field of  $514\frac{1}{2}$  scan lines in a period of 16.66 milliseconds. Normal blanking reduced this to  $481\frac{1}{2}$  active scan lines (a loss of 33 lines during the blanking period, a period which also encompasses the field retrace period). The horizontal frequency was 30870 Hz; this gave a line period of 32.4 microseconds. Line retrace time was adjustable for the tests and was about 5 microseconds. This gave an active line period of 27.4 microseconds. The major system for which the investigation could apply had an active line period of 25 microseconds and a retrace time of 7.4 microseconds.

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### SECTION IV

#### RESULTS

The results as well as descriptions of the five different systems investigated are as follows:

##### a. System "A"

(1) System description: The system consisted of four fields each consisting of  $514\frac{1}{2}$  lines. The sequence of developing the four-field frame is as follows: Field No. 1 consisted of odd lines being scanned horizontally from left to right and starting at the top of the raster area and progressing downward. Field No. 2 interlaced the first field by scanning the even numbered lines. Upon completion of Fields No. 1 and 2, the deflection circuits were so switched to produce Fields No. 3 and 4 in a direction  $90^\circ$  from the No. 1 and 2 fields. Field No. 3 followed No. 2 and scanned odd numbered lines from the bottom of the raster to the top and progressed from left to right. Field No. 4 interlaced No. 3 on the even numbered lines. The above sequence resulted in a raster consisting of 1029 lines in the horizontal direction and 1029 lines in the vertical direction. The aspect ratio was adjusted to give equal height and width of the raster in order to simplify deflection and timing requirements. Additionally, this reduced the upper cut-off frequency requirement by having fewer picture elements to produce per unit time. System "A" is illustrated in Figure 1.

(2) Results: Due to the small raster presentation on the 547 scope, the cross-scan raster exhibited no visible line structure; however, when expanded times 10, the effect was a clear grid with line structure in each direction equivalent to that of a 1029 line system displayed in a 15-inch raster height and width. The system produced significant flicker in alternate quarter sections of the raster. The flicker effect becomes significant about one-third the distance from the center along the diagonal and increases toward the corner. Both the upper right hand and the lower left hand corners are affected. It is a result of the area in question being scanned early in the period of No. 2 field and not again until late in the period of No. 3 field; and, similarly, with Fields No. 4 and No. 1. One such point, Element A, is noted in Figure 1.

It was also noted that special compensation of deflection circuits would be required to give the desired degree of registration of the cross scan. This was checked by designing a test bar generator and applying its signals to the raster to simulate a video input. Prior to this system test, some work was accomplished to show the feasibility of circuits that might provide the required compensation; however, this was not pursued at this time because of the flicker problem.

The cross bar pattern when displayed by the cross-scan scheme exhibited higher density at the points of intersection. This indicates there was an increase in data displayed in a given image area. The increase is a function of the number of active lines, the line height and the raster height. For a 15-inch high raster in a 1029 line system and a line height of .015 inches, the calculated increase in area covered by the cross-scan fields is 6.7

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percent. For the same area with  $514\frac{1}{2}$  lines crossing  $514\frac{1}{2}$  lines, the increase would be about 52 percent. If the area is decreased so that a given number of lines are overlapped by a specified amount, there may be little or no increase in data provided by the cross fields.

##### b. System "B"

(1) System description: In order to generate the same number of lines in the same period as for the single direction scan 1029 line system with 2:1 interlace, system B was devised. It consisted of  $514\frac{1}{2}$  lines in the first field scanned with horizontal lines and progressed from top to bottom of the raster area. The second field was scanned at  $90^\circ$  to the first, with vertical scan lines from bottom to top and with the field being generated from left to right. This gave a 60 Hz field rate and a 30 Hz frame rate, matching those of the single direction 1029 line system.

(2) Results: The raster exhibited the same type of flicker experienced with System "A," and for the same reason. Even though the basic field time is 16.66 Msecs (60 Hz), there are areas that time intervals up to 32 Msecs result between scans. It should also be noted that the overall effect of the raster is a gridwork of  $514\frac{1}{2}$  lines in each direction; the line structure is too coarse for the cross-scanning to reduce the appearance of line structure. As was noted near the end of paragraph a(2), above, the cross-scan under these conditions will add about 52 percent more data in 15 square inch raster area. Figure 2 illustrates System "B."

##### c. System "C"

(1) System description: To overcome the flicker effect of the above systems, System "C" was devised. It consisted of a cross-scan raster generated a line at a time in each direction; i.e., line 1 in the horizontal direction, line 2 in the vertical, line 3 in the horizontal, etc. In a normal field time of 16.66 Msecs,  $257\frac{1}{2}$  lines are crossed with  $257\frac{1}{2}$  lines, for a total of  $514\frac{1}{2}$  lines. At the end of  $514\frac{1}{2}$  lines, the raster is in position to start the interlace during the next 16.66 Msec period. The interlace, once started properly by the position of the first period, is generated in the same manner, line for line, as the first field. The field starts halfway across 515, falls to the left of line 2 in the cross field, line 517 falls between lines 1 and 3, etc. At the end of the second period, the frame is completed with a total of 1029 lines in the raster; i.e.,  $514\frac{1}{2}$  lines in each direction.

(2) Results: The raster was successfully generated without significant flicker. The line structure was a coarse  $514\frac{1}{2} \times 514\frac{1}{2}$  line grid. Although the timing is such as to produce a proper interlace in a straight 1029 line system, it did not produce proper interlace with the cross scan 1029 line system. The start of the second period is at the midpoint of line 515 in the center of the top of the raster; it is displaced from the start of the 1 by half a line (this is equivalent to 16.2 usecs for 32.4 usec scan line). Line 516 is a cross-scan line, therefore, the next interlace line is 517. It is spaced from line 1 by a space equivalent to 48.6 usecs and from line 3 by 16.2 usecs. This unequal spacing results in line pairing, another type of

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undesirable distortion. Although no attempt was made to correct this, it is probable that adjustments in timing and blanking can be made in order to achieve a proper interlace. Figure 3 illustrates System "C."

As was noted above, there is about a 52 percent increase in data content to a TV presentation when cross-scanning is used for the following conditions:  $514\frac{1}{2} \times 514\frac{1}{2}$  line raster in 15 x 15 inch area, with line height of 0.015 inches. The calculation is as follows:

$$514\frac{1}{2} - 33 = 481\frac{1}{2} \text{ active horiz lines, in each direction}$$

$$481\frac{1}{2}/15 = 32.1 \text{ lines per inch of height}$$

$$32.1 \times .015 = 0.48 \text{ or 48 percent of available height scanned}$$

$$1 - .48 = .52 \text{ or 52 percent of available height is space}$$

$$(.52 \times 1) - (.48 \times 1) = .25 \text{ sq inches area added by cross-scan}$$

$$.25/.48 = .52 \text{ or 52 percent added area.}$$

#### d. System "D"

(1) System description: In an attempt to produce a flicker-free raster with a 1029 line structure in each direction, the following was devised and tested. The field time was cut in half (8.33 Msecs, a 120 Hz rate). The total frame was divided into two subframes, one in each cross direction. Each subframe consisted of four fields interlaced 4:1. All fields were generated in sequence, one through eight, with cross field switching taking place between Fields 4 and 5.

(2) Results: Significant flicker resulted; apparently between subframes. This was not predicted, but there may have been enough displacement between every fourth field due to the interlace to cause the effect. There was no isolated area flicker as in systems A and B. This was expected since there was no time separation between given areas being scanned that exceeded 16 Msecs. Line crawl was expected as a direct effect of the 4:1 interlace; however, with the small presentation available this was not noticeable. It is obvious that with such a complex system that interlace phasing and timing are quite critical. Figure 4 illustrates System "D."

#### e. System "E"

(1) System description: Although not a true cross-scan system, the following is a variation that would hopefully be free of flicker and at the same time break up the appearance of line structure. A normal sub-field with 2:1 interlace was generated, left to right; the deflection direction was then reversed to generate another sub-field with 2:1 interlace, right to left. Since the line pitch is the same in both directions, this resulted in each line being crossed by a line from the opposite direction. Three crossovers occurred across the raster with lines from one field converging with those of the counterpart field from the opposite direction. This scheme was performed with  $514\frac{1}{2}$  lines per field, 1029 lines per frame. The field rate was 60 Hz and frame rate 15 Hz.

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(2) Result: Significant flicker resulted at the sides of the raster; apparently as a result of every other field converging at the sides and occurring at a time separation 33.32 Msecs which yields the 30 Hz rate. The cross over points did not produce an undesirable pattern on the small presentation; possible this would be troublesome in a large raster where line structure would be more pronounced. Figure 5 illustrates System "E."

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### SECTION V

#### CONCLUSIONS

Although this initial investigation merely scratched the surface of possible avenues of research in developing unique scan systems, certain aspects were demonstrated that provided useful information for the prediction of results on similar but different concepts that might be considered. For instance, any pair of events occurring sequentially and separated in time by over 24 Msecs will produce the flicker effect. Flicker is more pronounced when scan lines or fields are not in the same direction.

It is evident that the cross-scan concept is feasible and can be used to advantage under certain conditions. A cross-scan of  $514\frac{1}{2}$  lines in each direction does not produce flicker but when displayed in a 15-inch raster height produces a very coarse line structure. To correct this, the raster height would have to be reduced to less than 7 inches; the resulting raster would be equivalent or better than a 1029 scan raster in 15 inches. To achieve a raster of greater height, maintaining the same line density, the number of scan lines would have to be increased. This, of course, would demand a greater bandwidth. A system of 1029 lines per field in a period of 16.66 Msecs would require a frequency response capability up to about 36 MHz.

Cross-scanning can also result in flicker which develops in two of the quarter sections of the raster area. This is a result of the area in question being scanned early during one field period and not again until the end of the adjacent cross-scan period. This is true even when the field rate is at the normally flicker-free rate. Line-to-line cross switching can in some cases eliminate this effect.

It was also noted that the higher line density yielded a smaller percent of data improvement by the addition of the cross-scan than could be gained by adding the cross scan to the lower line density systems. It is obvious that as the spaces between diminish, there is less area to be filled in by the cross-scan field; in fact, when the lines are brought together and overlapped to the extent necessary to produce a flat field, there is possibly no gain or new information added by the cross-scan field.

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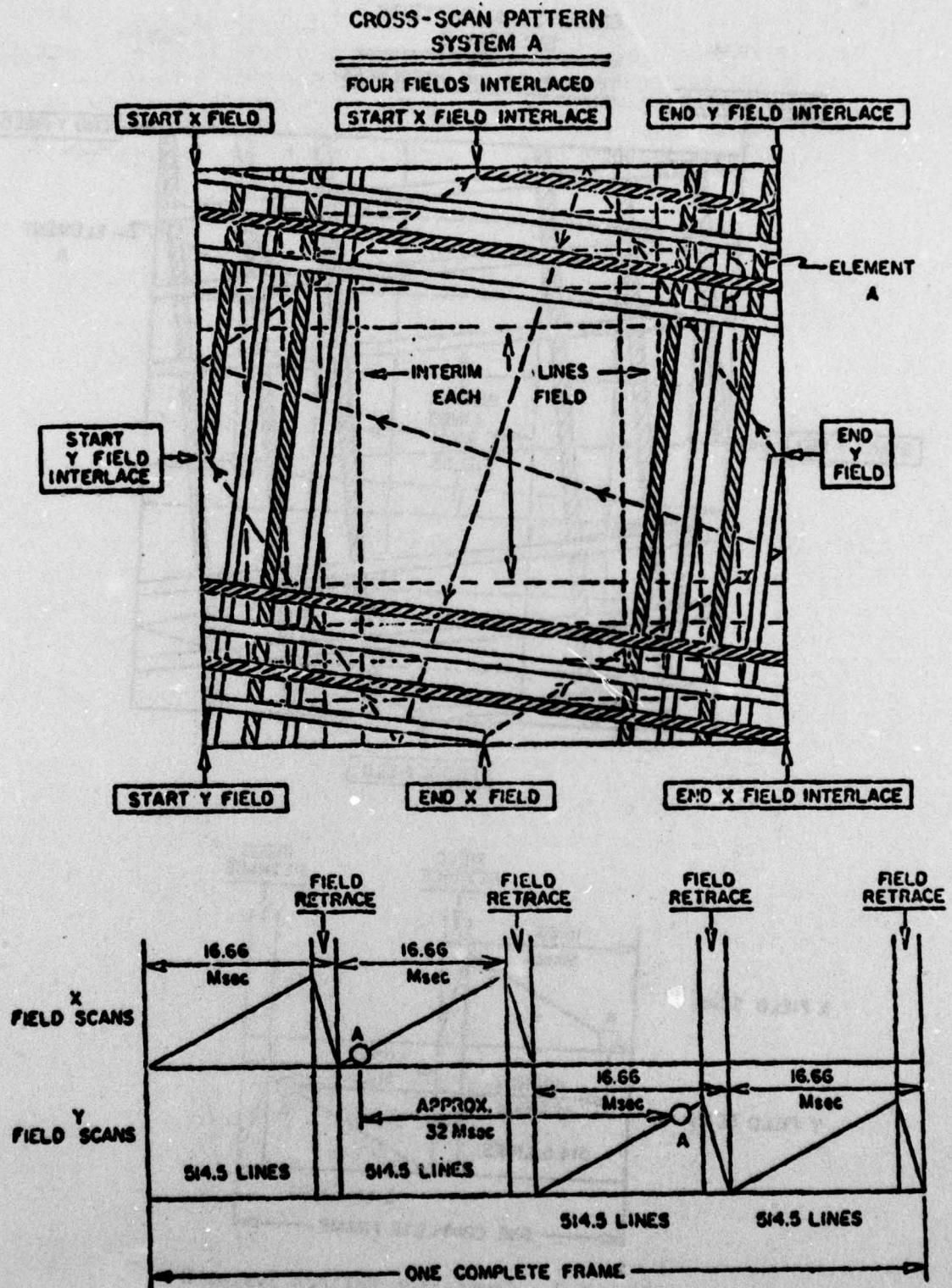


Figure 1. Cross-Scan Pattern System A

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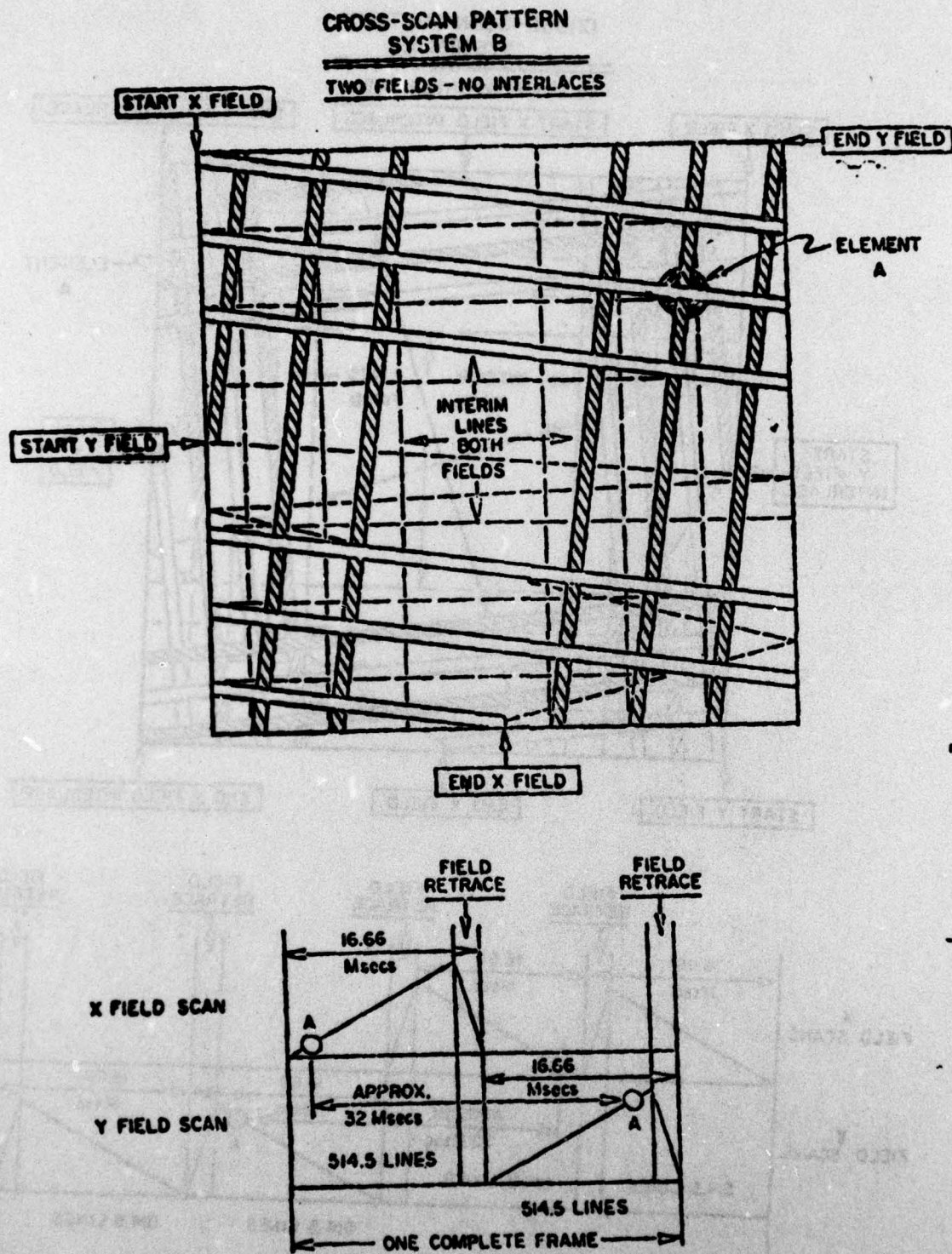
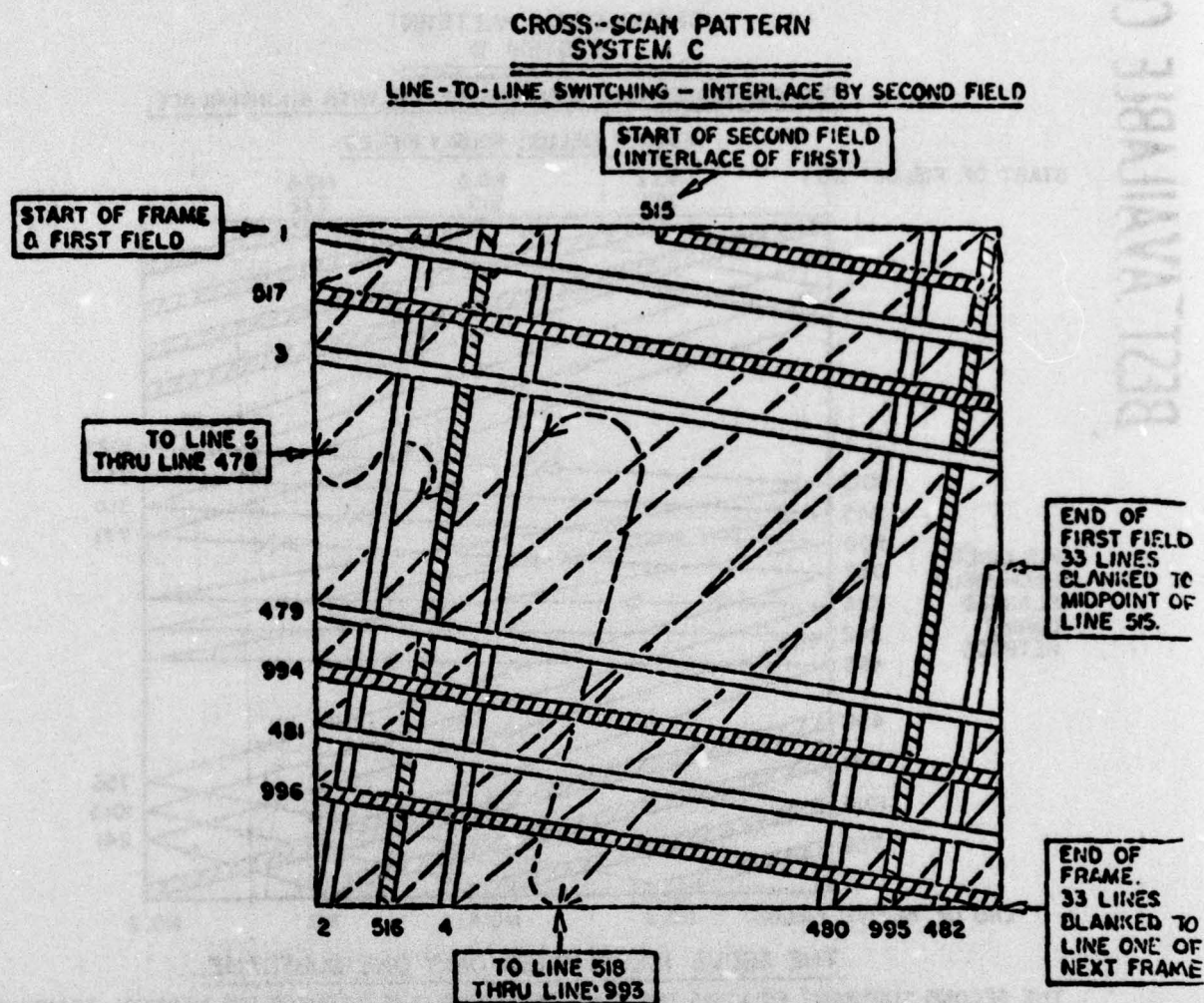


Figure 2. Cross-Scan Pattern System 8

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TOTAL NUMBER OF SCAN LINES: 1029 FIELD RATE: 60 Hz FRAME RATE: 30 Hz

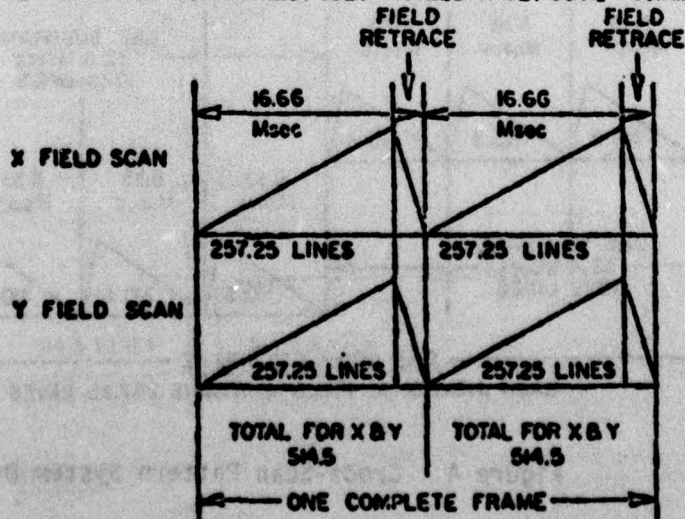
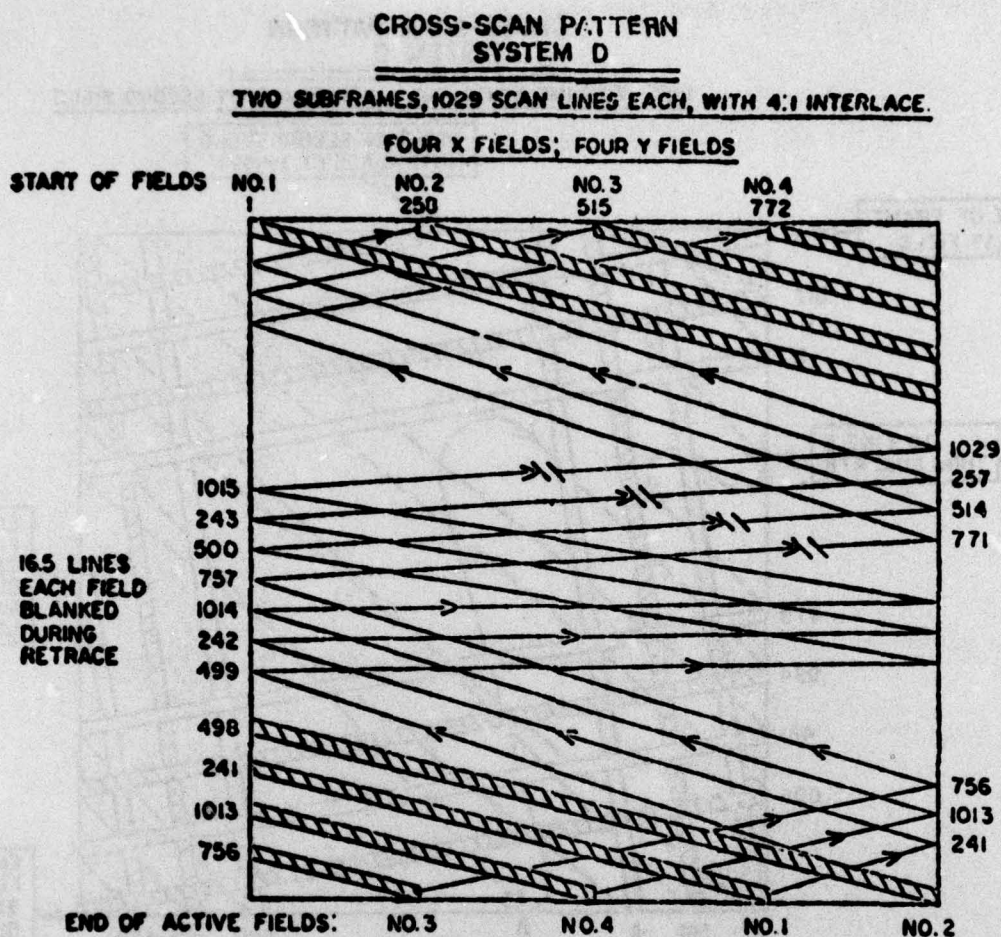


Figure 3. Cross-Scan Pattern System C

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THE ABOVE ILLUSTRATES ONLY ONE SUBFRAME.  
THE SECOND SUBFRAME FOLLOWS THE SAME PATTERN BUT IS ORIENTED FOR VERTICAL SCANNING.

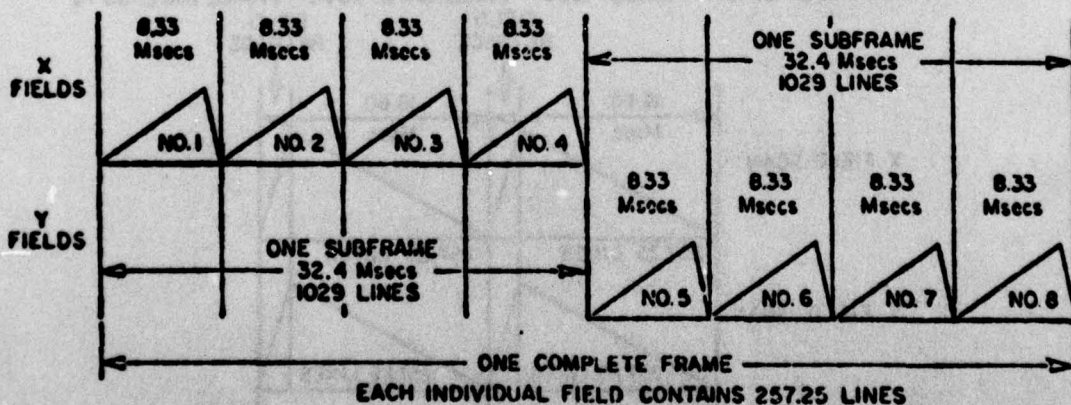


Figure 4. Cross-Scan Pattern System D

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## REVERSE-SCAN PATTERN SYSTEM E

1029 LINES, 2:1 INTERLACE, LEFT-TO-RIGHT PLUS 1029 LINES, 2:1 INTERLACE, RIGHT-TO-LEFT.  
FIELD RATE: 60Hz FRAME RATE: 15Hz

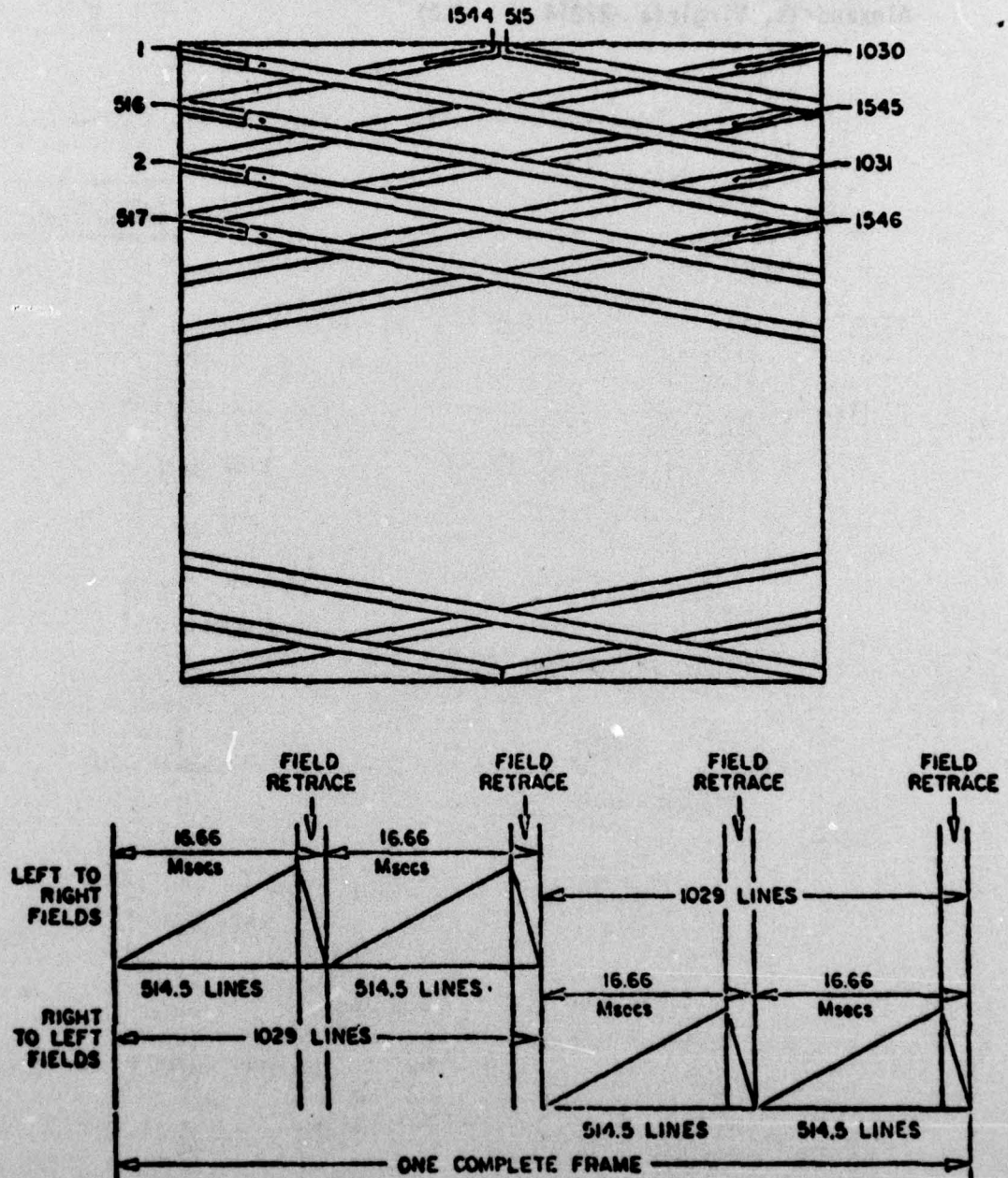


Figure 5. Reverse-Scan Pattern System E

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